



Intermittency Analysis Project

Results for Tasks 3+4

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Intermittent Generation Definition

- Wind
 - Variations cover many timescales
 - Season, day, hour, minute
- Solar
 - Variations are dominated by day/night cycle and sky conditions (clouds, . . .)
- Biomass and geothermal generation are not intermittent



Objectives

- Evaluate California grid operation with increasing levels of intermittent generation
 - Penetration of wind and solar up to renewable policy levels
- Identify and quantify system performance and operation problems
 - Load following, regulation, minimum load, etc.
- Identify and evaluate possible mitigation methods



Four Scenarios Analyzed

- 2006 Base Case – Existing transmission system with existing mix of generation resources
 - Includes 2100 MW wind and 330 MW solar
- 2010T Tehachapi Case – 20% Renewable Energy
 - 7500 MW wind and 1900 MW solar in California
 - Includes 4200 MW of new and existing wind in Tehachapi region and new 500 kV transmission to support it
- 2010X Accelerated Case – 33% Renewable Energy
 - 12500 MW wind and 2600 MW solar in California
 - Interim infrastructure with most of 2020 intermittent renewable generation
- 2020 Case – 33% Renewable Energy
 - 12700 MW wind and 6000 MW solar in California



Four Scenarios - Overview

	2006	2010T	2010X	2020
Peak California Load, MW	58,900	62,600	62,600	74,300
Peak CAISO Load, MW	48,900	51,900	51,900	61,200
Total Geothermal, MW	2,400	4,100	3,700	5,100
Total Biomass, MW	760	1,200	1,000	2,000
Total Solar, MW	330	1,900	2,600	6,000
Total Wind, MW	2,100	7,500	12,500	12,700
Wind at Tehachapi, MW	760	4,200	5,800	5,800
CA Intermittent Capacity Penetration	4%	15%	24%	25%
CAISO Intermittent Capacity Penetration	5%	18%	29%	31%

Wind and Solar Generation in California

	2006	2010T	2010X	2020
Concentrating Solar (CS)				
Number of Sites	7	12	42	43
Total CS MW	330	1200	2100	3100
Photovoltaic (PV)				
Number of Sites	0 *	136	128	228
Total PV MW	0 *	630	530	2900
Wind Plants				
Total Sites in CA	57	98	142	147
Sites in Tehachapi Region	16	40	54	54
Total Wind MW	2100	7500	12500	12700

* Existing PV aggregated with load

Locations of Wind and Solar Resources

Scenario 2010T

	Wind		Solar		Total Wind+Solar	
	MW	%	MW	%	MW	%
CAISO	7300	97%	1700	89%	9000	96%
Non-CAISO	200	3%	200	11%	400	4%
Total CA	7500	100%	1900	100%	9400	100%

Scenario 2010X

	Wind		Solar		Total Wind+Solar	
	MW	%	MW	%	MW	%
CAISO	11600	93%	2300	88%	13900	92%
Non-CAISO	900	7%	300	12%	1200	8%
Total CA	12500	100%	2600	100%	15100	100%



Types of Analysis

- Statistical Analysis
 - Multiple time periods (Hourly, 5-minute, 1-minute)
- Production Cost Simulation with MAPS
 - Hour-by-hour simulation of GRID OPERATIONS for an entire year (3 years of different wind and load profiles)
- Quasi-Steady-State Simulation with PSLF
 - Minute-by-minute time-sequenced power flows for entire WECC grid for several hours
- Transient Stability Simulation with PSLF
 - Considered, but based on the analysis of California wind and load data, it was judged unnecessary to address the relevant intermittency issues





Data

- Powerflow data from Davis Power Consultants
 - Scenarios 2006, 2010T, 2010X, 2020
- Load data from CAISO, 2002-2004
 - Hourly load MW, forecast and actual
 - 4-sec load MW for about 400 days
 - Load data scaled up to peak for 2006, 2010, 2020
- Wind data from AWS Truewind, 2002-2004
 - Hourly wind MW, forecast and actual
 - 1-minute wind MW for 51 selected periods
 - Separate wind profile data for each wind farm
- Production simulation data for California and WECC compiled by Rumla, Inc. from multiple sources



Data

- Solar data from multiple sources
 - Hourly and 1-min MW for Sungen and Luz for 2002-2004 (CAISO and UC-Davis)
 - Hourly Stirling solar MW for Mojave and Imperial for 2002-2004 (NREL and SES)
 - Hourly and 15-min Photovoltaic MW for one year, aggregated by zip code (CPUC - SGIP)
 - 1-min and 3-min solar insolation data at two sites, for January and July 2002 (NREL, ARSC SUNY Albany)

Based on this data, GE compiled solar profiles for multiple sites across California





Terminology

- 1-hr Delta: Change from the previous hour
- Schedule Flexibility
- 5-min Delta: Change from previous 5-minute period
- Load Following, Economic Dispatch
- 1-min Delta: Change from the previous minute
- Regulation



Feedback from August 15, 2006 Workshop

- Written comments and questions submitted by CAISO, CalWEA, and PG&E on a variety of topics
 - Operation with high wind during light load periods
 - Adequate maneuverability to keep up with ACE
 - Hydro operation during heavy spring runoff
 - Ramping requirements for future generation additions
 - Summarize problems and potential solutions
 - Need for quick-response generation or load
 - Are all existing wind and solar generators represented individually?
 - Details of data used in model (*more details included in report*)
 - Quantify integration costs of renewables
 - Need for ramping and regulation capability within CAISO area
 - Impact on spot prices
 - Feasibility of grid operation with 33% renewable energy



Presentation Outline

- Statistical Analysis -- Nick Miller
- Production Simulation Analysis -- Gary Jordan
- Quasi-Steady-State Analysis, QSS -- Kara Clark
- - - 10-minute BREAK - - -
- Operational Implications and Mitigation Methods
- Conclusions and Recommendations

Focus on impacts due to intermittency in MW

✓ *Cover lots of material*

➔ *Focus on work performed since August 15 Workshop*

✓ *Give an overview of types of analysis performed*

✓ *Complete results documented in final report*